KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDUCATION

SPH 101: ELECTRICITY AND MAGNETISM 1

DATE: Friday, 12th May 2017 **TIME: 11.00 a.m. - 1.00 p.m.**

INSTRUCTIONS:

Answer question ONE and any other TWO (2) questions. Question ONE carries 30 marks while each of the others carries 20 marks.

Some constants which you may find useful

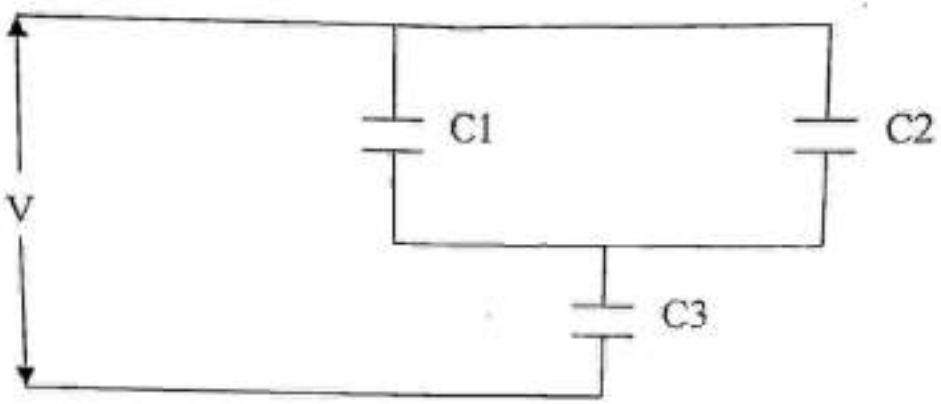
Magnitude of the charge of an electron, e	1.6×10^{-19} C
Acceleration due to gravity, g	9.81 ms^{-2}
Value of $k = \frac{1}{4\pi\varepsilon_0}$	9×10^9 mF^{-1}
Mass of an electron, m_e	9.11×10^{-31} kg

1. (a) State Coulomb's law. What will be the line of action of the force on a charge placed on the perpendicular bisector of the line joining two equal and like charges? Explain your answer. (5 marks)

(b) Find the magnitude and direction of the electric field which can balance the weight of an electron. (5 marks)

(c) According to the Bohr model of the hydrogen atom, it consists of a proton circled by an electron whose orbit has a radius of 5.3×10^{-11} m. Show that the magnitude of the electric potential energy in this model of the hydrogen atom is twice the electron's kinetic energy. (5 marks)

(d)(i) In the following combination find the equivalent capacitance assuming that $C1 = 1\mu F$, $C2 = 2\mu F$, $C3 = 3\mu F$ and $V = 30$ Volts. (2 marks)



(ii) Find the magnitude of the charge on the plates of each capacitor. (3 marks)

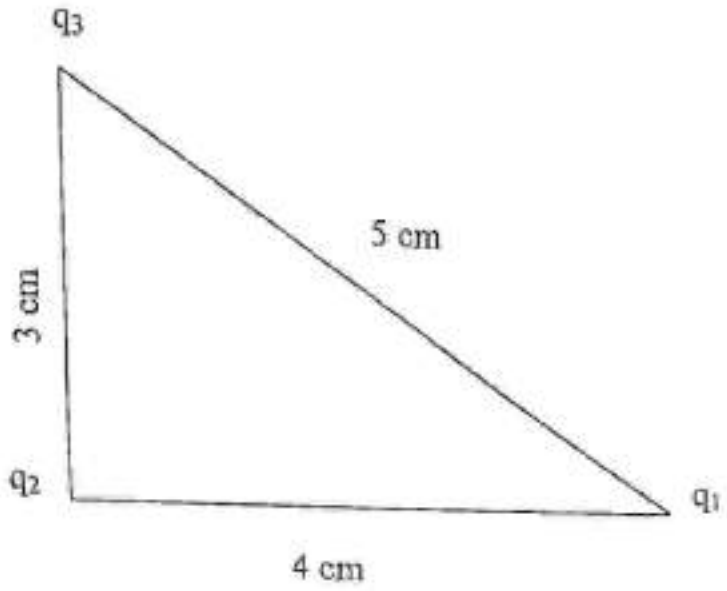
(e) The material of an electric wire (length 1.1m, cross sectional area $= 3.1 \times 10^{-6} m^2$) has a resistivity of $\rho_0 = 6.8 \times 10^{-5}$ Ω.m at $T_0 = 320\ ^0C$ and a temperature coefficient of resistivity $\alpha = 2.0 \times 10^{-3}/\ ^0C$. Determine the resistance of the wire at a temperature of $420\ ^0C$.

(5 marks)

(f) A battery has an emf of 15 V. The terminal voltage of the battery is 12 V when it is delivering 15 W of power to an external load resistance R. Find R and the internal resistance of the battery.

(5 marks)

2. (a) Three charges $q_1 = +3$ nC, $q_2 = +4$ nC and $q_3 = -5$ nC, are located as shown in the figure below.



Find the magnitude and direction of the net force on q_1. (8 marks)

(b) A thin non-conducting rod of finite length L carries a total charge Q spread uniformly along it and is characterized by a linear charge density $\lambda = \frac{Q}{L}$. Find electric field **E** at a point P on the perpendicular bisector of the rod at a distance y from the rod. (6 marks)

(c) An electric dipole consists of two point charges, + 10 nC and – 10 nC placed 4 cm apart. Compute the potentials at

(i) a point on the perpendicular bisector of the line joining the two charges, (3 marks)

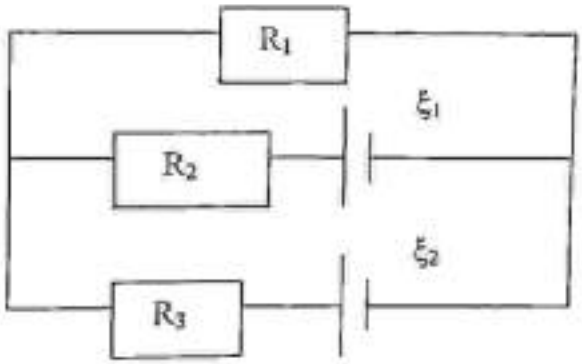
(ii) a point along the axis of the dipole and 4 cm from the centre of the dipole towards the positive charge. (3 marks)

3. (a) A capacitor $C_1 = 2\mu F$ is charged to a potential difference of 100 V. Charging battery is then removed and the capacitor is connected, as shown in the figure, to an uncharged capacitor $C_2 = 4\mu F$.

(i) What is the potential difference across the combination? (5 marks)

(ii) What is the stored energy before and after the two capacitors are connected together? Comment on the difference. (5 marks)

(b) Apply Kirchhoff's laws to find the current passing through the resistor R_1 in the circuit given below. It is given that $R_1 = 1.20\ \Omega$, $R_2 = 0.01\ \Omega$, $R_3 = 0.10\ \Omega$, $\xi_1 = 12.0$ V and $\xi_2 = 14.0$ V.



(6 marks)

(c) A 250 W electric heater is designed to operate from 120 V lines.

(i) What is its resistance? (2 marks)

(ii) What current does it draw? (1 mark)

(iii) If the line voltage drops to 100V, what power does the heater take? (1 mark)

4. (a) A galvanometer gives full scale deflection for a current of 0.02 A and has a resistance of 50 Ω.

(i) How can it be converted into a 4A ammeter? (4 marks)

(ii) How can it be converted into a 5V voltmeter? (4 marks)

(b) An emf of 1.5 V of a battery is balanced by 30 cm length of a potentiometer wire. What is the potential gradient in the wire? (2 marks)

(c) An electron is moving in a circular orbit of radius 0.1m in a plane at right angles to a uniform magnetic field of 1.0×10^{-5} T. What is the speed of the electron? (5 marks)

(d) A charged capacitor is being discharged through a resistor. Near this circuit of the discharging capacitor and resistor, a coil with a galvanometer connected to it is placed such that the magnetic field associated with the current in the circuit of the discharging capacitor passes through it. At what instant of the discharging of the capacitor (from the start of the discharging ($t = 0$) to the time when the capacitor is fully discharged), will the deflection in the galvanometer be maximum? Explain your answer. (5 marks)

5.(a)(i) State Faraday's law of electromagnetic induction. (2 marks)

(ii) A 12 turn coil 10 cm in diameter has its axis parallel to a magnetic field of 0.5 T which is produced by a nearby electromagnet. The current in the electromagnet is cut off, and as the field collapses an average emf of 8V is induced in the coil. What was the length of time required for the field to disappear? (4 marks)

(b) A battery of emf ξ and negligible internal resistance is switched on in a circuit containing an inductance L and a resistance R. When the equilibrium current is established, the battery is suddenly removed and the inductance and the resistance are connected together. The current in the LR circuit starts decaying. Derive an expression for the decay of the current with time in the circuit. Hence define the time constant and explain its physical significance. (8 marks)

(c) A series circuit containing a 4.0 H inductance and a 12.0 Ω resistance is connected to a 15 V battery of negligible internal resistance. When the equilibrium current is

established, the battery is suddenly removed and the inductance and the resistance are connected together. The current in the LR circuit starts decaying. Find

(i) The initial rate of decay of of the current in the circuit (2 mark)

(ii) The rate of decay of current at the instant when the current is 1.0 A. (2 marks)

(iii) The current 1second after the decay started. (2 marks)

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